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Prototype of a Smithfield Nutrient Cover

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Prototype of a Smithfield Nutrient Cover

Problem Statement

Smithfield Hog Production has processing facilities throughout the state of Iowa as well as contract finishing sites where producers grow out their swine. The hog manure from these sites is pumped into a slurry store for storage until it can be pumped onto the fields in the spring or fall. The slurry stores stand 19-feet-tall, have a diameter of 120-feet, and hold 1.2-million-gallons of manure. The slurry stores have no cover so they are open to all weather like rain and snow.

Most years, evaporation does not equal precipitation which results in a decreased manure holding capacity and an increased cost to pump the manure. The precipitation that accumulates in the tank also lowers the per gallon value of the nutrients as a crop fertilizer due to dilution. A cover for the slurry tanks would eliminate precipitation from entering the tank.

Disciplines

Bioresource and Agricultural Engineering | Industrial Technology

IOWA STATE UNIVERSITY

Department of Agricultural and Biosystems Engineering (ABE)

TSM 416 Technology Capstone Project

Prototype of a Smithfield Nutrient Cover

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Client: Smithfield Foods, 2124 90th Ave, Algona, IA, 50511, www.smithfieldfoods.com

- Contacts: Robert Coffelt, Organizational Improvement Manager, bcoffelt@smithfield.com, 172-229-8899; Scott McLaughlin, Environmental Resource Manager, smclaughlin@smithfield.com, 712-571-7024; Kelly Welter, Environmental Resource Manager, kwelter@smithfield.com, 712-229-3492

1 PROBLEM STATEMENT

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Business Case Statement

- Smithfield foods have requested a solution to keep the 30 inches of rainwater out of company slurry tanks to lower the costs of pumping and increase the nutrient value of the manure being stored in the tank
- The cover needs to have a return on investment that is achievable within the life of the cover.
- The cover should be semi removable to allow pumping in the fall, removal during the winter months to avoid snow load, and mixing through the summer.
- The cover needs to be removable with a few people or common equipment within a few hrs.

2 MAIN OBJECTIVE

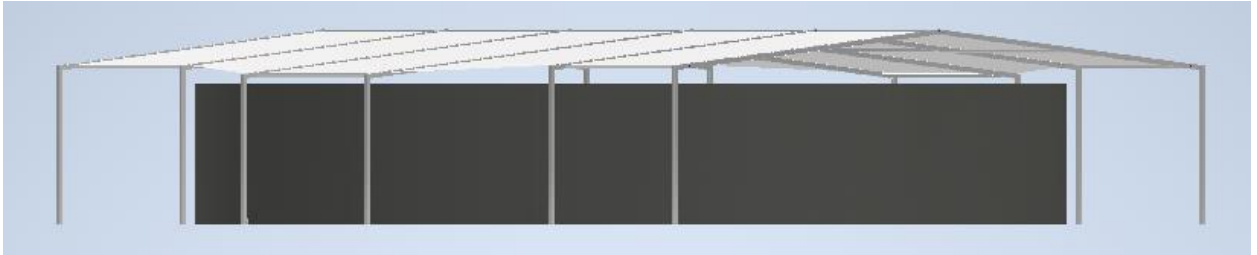
- **Main Objective**
 - Create a cover for slurry stores that will be cost-effective and reduce the accumulation of precipitation in the tank to less than 1% rainwater.
- **Specific Objectives include**
 - The tarp should shed all water away from the tank and have a free-standing frame not connected to the tank in any way.
 - The solutions to have easy annual installation after winter and removal to allow access to the tank.
 - The cover must stand up to a total of 30 inches of rain collected from heavy spring, summer, and fall rains.
 - The solution must be able to withstand extensive yearly Iowa winds.
- **Rationale**
 - A successful solution will provide Smithfield with a structurally sound framing and tarp proposal that has an achievable return on investment due to lower annual fall pumping costs.
- **Project Scope**
 - The project focused on developing a cover that would keep rainwater out of the slurry tanks and would be easy to install and remove. We also considered the cost of initial implementing the cover and annual repair

3 RESULTS

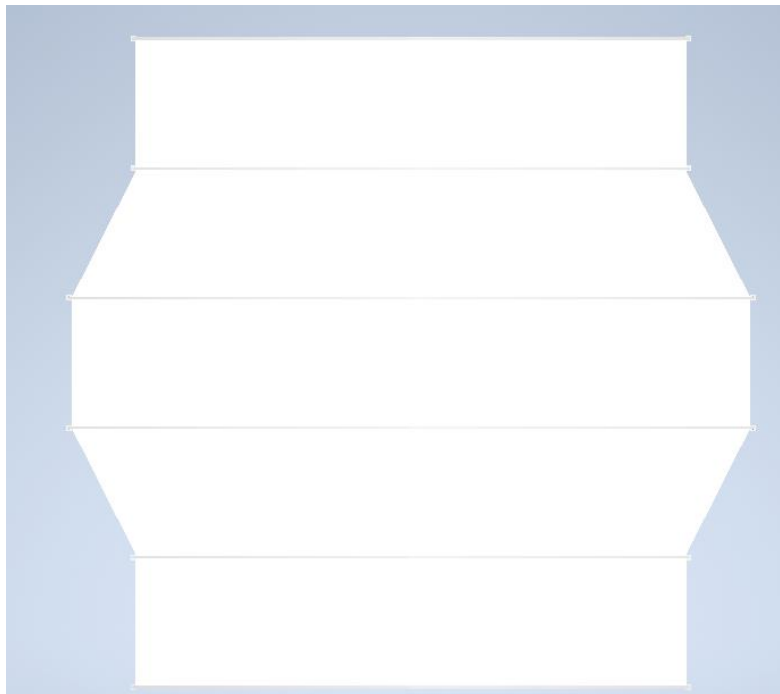
Results/Deliverables

- Developed a cover on AutoCAD which meets the client's needs of keeping rainwater out of the slurry tank
- The cover is easily installed and removed.
- The frame that holds the cover is structurally sound.

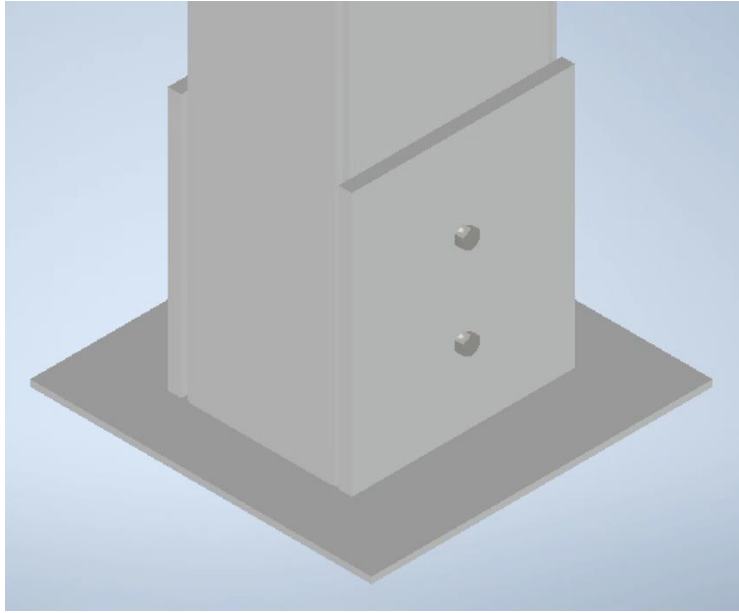
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- **Figure 1**
 - Side profile of final assembly.
 - The cover is 25' at the peak and has twelve 20' legs.
 - The frame is made of aluminum.

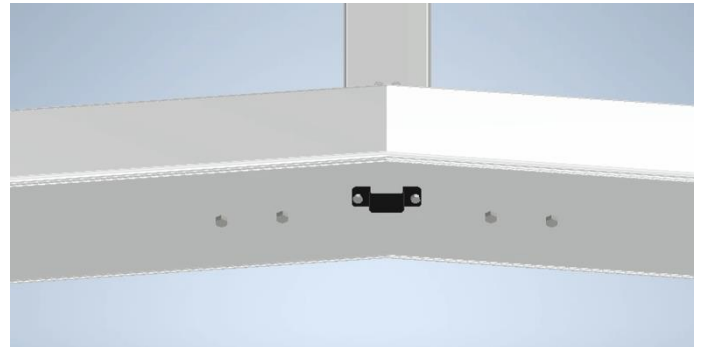
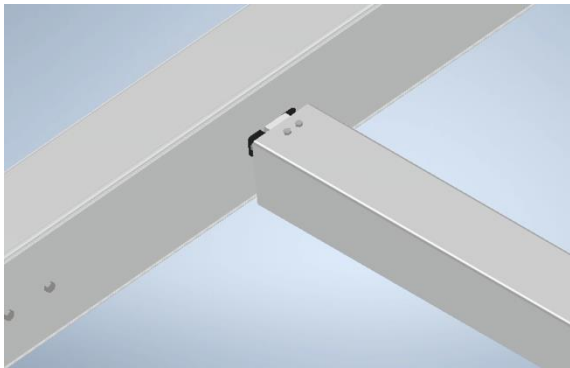


- **Figure 2.**
 - In this top view of the assembly, it is visible to see the assembly is split up into five 25' long sections for a total length on 125', and each side has a 2'6" overhang on each side.
 - Each section is also removable to allow fall pumping, regulatory stirring, and removing tarps for winter storage.
 - The Material the cover will be made of is a billboard like canvas.



- **Figure 3.**

- These feet are 1' by 1' at the bottom of the legs and will be anchored into small concrete pads poured around the tank.
- The purpose of this is to help keep the tarp and frame on the ground during a wind storm.
- There will be a total of 12 pads, one for each leg.
- The material the legs should be to aluminum as the rest of the framing.



- **Figures 4 and 5**

- These pictures represent how the cross beams are being connected.
- There are a total of 21 cross beams for supporting the structure.
- Each structural support beam will be locked together from both sides.

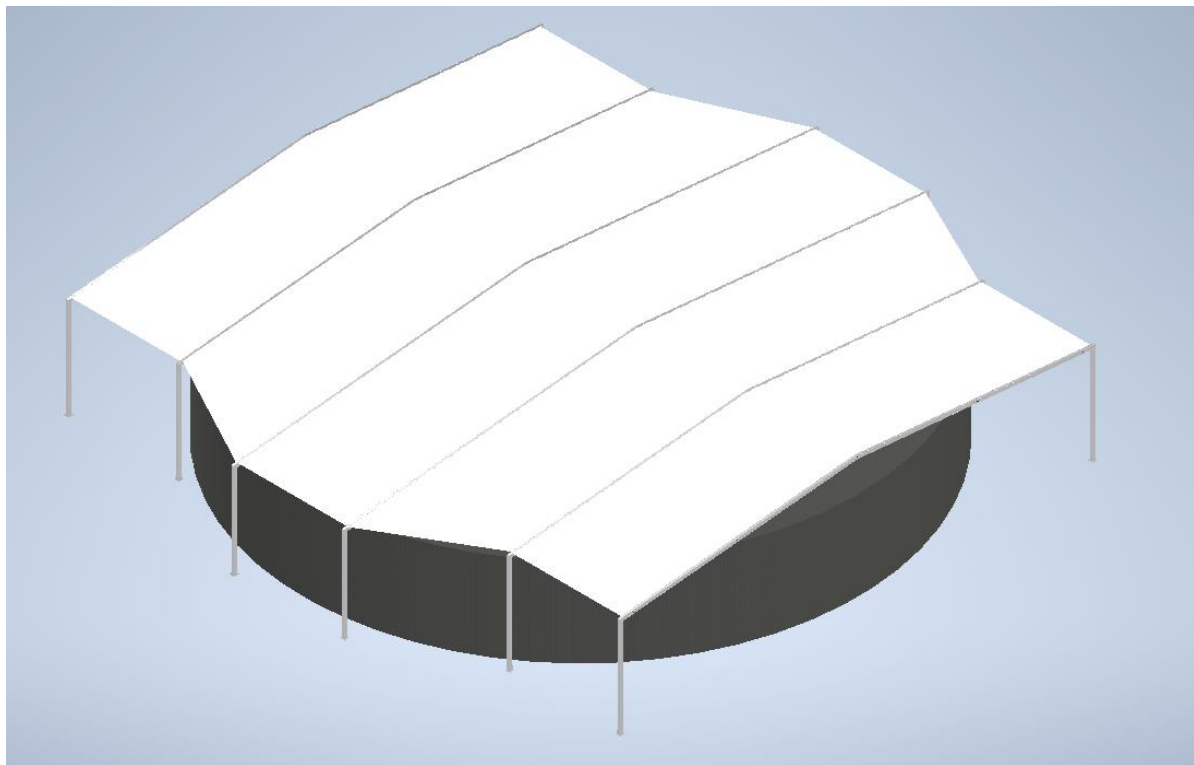
Recommendations

- Next year's capstone team will need to double-check our work on the structural soundness of the frame. (See references for who to contact on this.)
- Do a more in-depth cost analysis of our design, which would involve going directly to manufacturers to find prices of materials.
- Develop solutions for how the tarp will be secured to the frame.
- Develop a cable and center strut; an analysis of the best way to attach the cable to the frame will need to be done. (See appendix for specifics)
- Smithfield Hog Production will need to take a more in-depth look into whether a cover over the slurry tanks will actually be cost-effective with multiple unit production.

4 BROADER OPPORTUNITY STATEMENT

Our cover design will provide Smithfield with a cover that fits their needs of being structurally sound and easy to install and remove. Smithfield can also adapt our cover design to fit concrete manure storage structures or earthen basins. Any company that deals with waste holding structures will benefit from our cover even if it doesn't fit their exact needs as it can be modified.

5 GRAPHICAL ABSTRACT



6 METHODS/APPROACH

A. Methods/Approach

- **Data collection:**
 - One of the first things we did last fall was met with the Smithfield team over the phone and in person, where we learned all the size and dimensions of a slurry tank. We also came to an agreement on that in all calculations, we should assume 30 inches of rain every year will collect in an uncovered slurry tank.
- **Skills:**
 - The skills we used were AutoCAD skills, project management, communication, and statics.
 - The classes that helped us with that were TSM 216/116 (AutoCAD), TSM 214 (Project management), TSM 201 (Communication), and TSM 443 (Statics)
- **Solution:**
 - A wide variety of concepts and ideas were considered that can be seen in the appendix.
 - The final solution we decided on was based on 2 concepts, and the decision to combine the 2 concepts was made by the Smithfield Foods team.
 - Things considered in the final design were the cost of fabrication and installation compared to yearly savings.
 - Ability to stand without contacting the tank.
 - Being able to withstand all Iowa weather conditions spring through fall.
- **Organization:**
 - The team tried to meet twice a week including a meeting we had with professor Koziel and professor Anderson. We also held biweekly conference calls with Smithfield to give them updates and ask them any questions we have.

7 REFERENCES

Travis Hosteng

- Helped find the structural stability of our design.
- Made suggestions to help with structural soundness.

Documents:

“Clearspan Tent Structures.” Shelter Structures America, www.shelterstructuresamerica.com/.

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8 APPENDIXES

Cost Savings Estimation: The following excel table shows what we estimate to be the average cost savings per year if slurry tanks had a cover that would keep all the rain water out. The total savings per year is equal to \$4,512, that number will vary every year based on actual rainfall. Cost savings is important to find in order to estimate a reasonable budget and ROI.

Rain/Yr(ave)	2.67	ft	Tank Dimensions			
Area of Tank	11309.73	ft ²		Height	19	ft
Area of Rain in Tank	30159.67	ft ³		Diameter	120	ft
gal/ft ³	7.48	gallons		Radius	60	ft
Gallons of rain in tank	225609.99	gallons		Area	11309.73	ft ²
Cost to pump 1 gallon	0.02	\$				
Cost to pump Rain Water	4512.20	\$				
Used an average of 32 inches of rain per year, this is Central Iowa's average rainfall.						
Estimated the cost to pump 1 gallon at \$0.02 or 2 cents.						
Cost savings per year is equal to \$4,512.2						

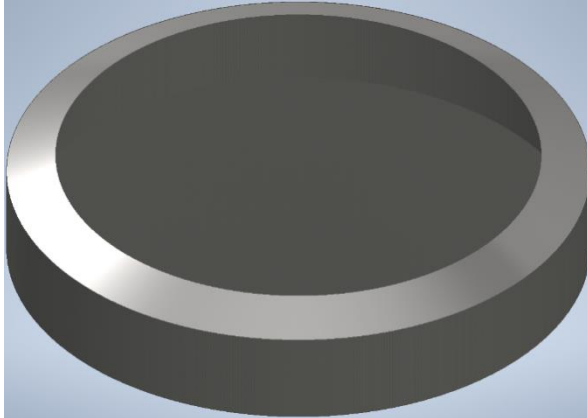
Weight of Structure with Cover: We also calculated the weight of our structure in order to get a better understanding of how structurally sound it would be. The following table shows each individual part, quantity, and weight. The weight used to determine structural soundness does not include the weight of the poles since their weight will not be exerted on the cross beams.

Frame Weight								lbs	
	Part	Dimensions	Qty	Weight/Beam(lbs)	Total Weight(lbs)			Frame Weight	3858.9226
	60.3 ft. Beam	8.5 x 6 x 0.13	4	262.5475	1050.19			Tarp Weight	2343.75
	48.37 ft. Beam	8.5 x 6 x 0.13	8	210.604	1684.832			Total Structure Weight	6202.6726
	Supports	5 x 5 x 0.12	17	66.1118	1123.9006				
Total					3858.9226				
Tarp Weight	ft^2	lbs/ft^2	Total Weight(lbs)		Weight doesn't include weight from nuts & bolts or Pole weight.				
	15625	0.15	2343.75		Total weight is 6,203 pounds.				
We constructed the frame to hold 7,000 lbs for safety precautions.									
This relatively light frame and cover considering the the area it spans.									
Pole Weight	Dimensions	Qty	Weight/Leg(lbs)	Total Weight(lbs)					
	8.5 x 6 x 0.13	12	91.4344	1097.2128					

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Proposed Slurry Tank Concepts:

- Concept 1:
 - One of the concepts was to put a cover around the outside portion of the tank that was roughly 10 ft wide. The idea was that it might be more comfortable and cheaper to cover part of the tank than the whole tank. This idea was scrapped as it did not show enough cost savings for it to be worthwhile.

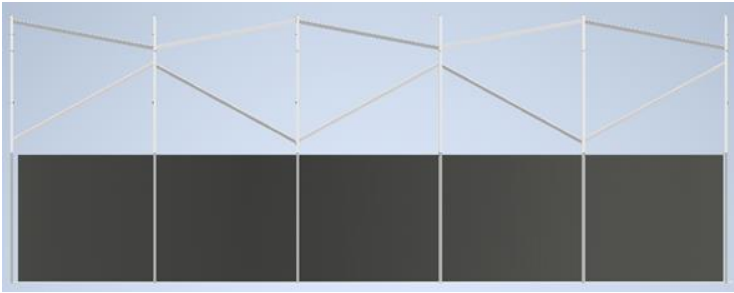


Pros	Cons
<ul style="list-style-type: none">○ Less total material to cover only part of the tank.○ Cheaper to cover only part of the tank	<ul style="list-style-type: none">○ Harder/unable to pump from over the top○ Keeps less rainwater out.○ Not enough total cost savings to implement.

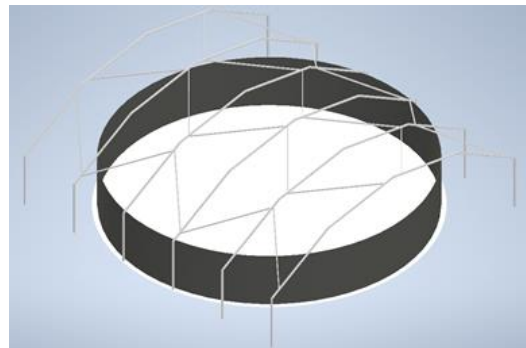
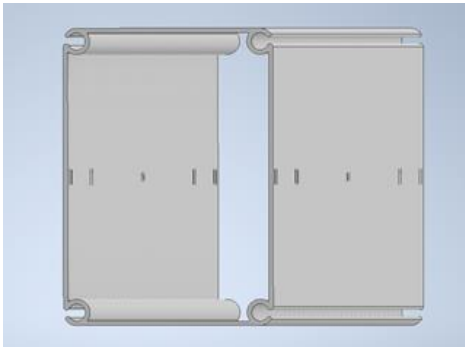


○ **Concept 2:**

- Permanent Tent Frame - This concept would use the same system as large tents in using the same type of framing and the same system to put on the tarps. This idea allows for very easy installation and removal of the tarps that will cover the tank. Our main design that we ended up going with resembles this idea most closely.

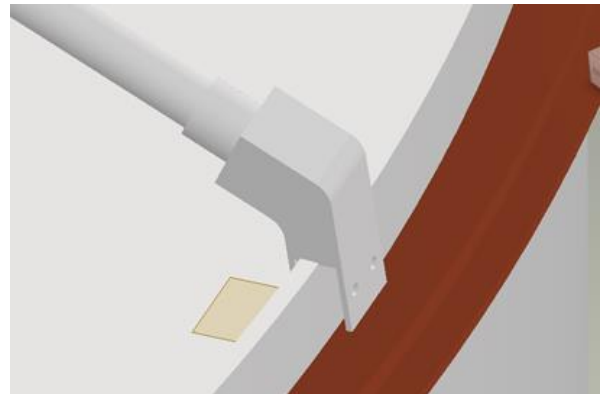
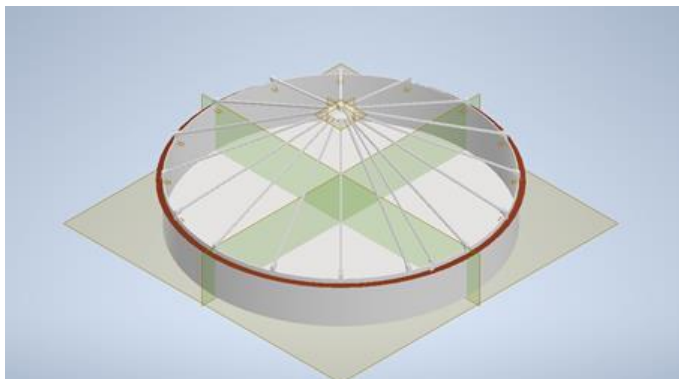


Pros	Cons
<ul style="list-style-type: none">○ Tarps are easy to remove during pumping○ Holds all rain water out	<ul style="list-style-type: none">○ Complex Fabrication○ Expensive and high ROI○ Very tall peak height

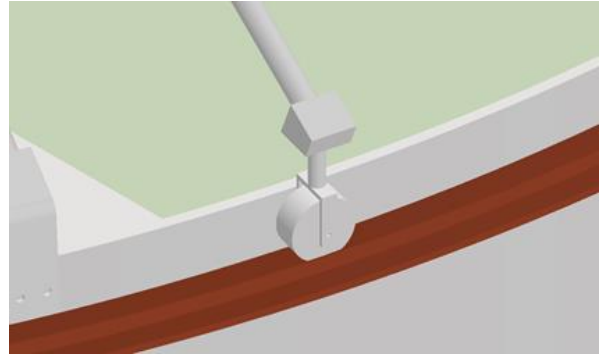
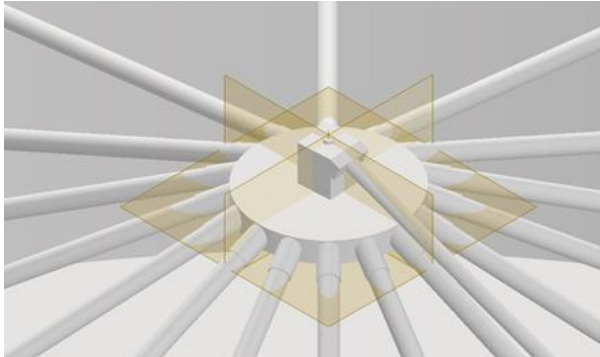


○ **Concept 3:**

- Automatic Tarp Roller - This design would use a frame consisting of bars extending from the side of the tank to the central hub over the center of the tank. A tarp roller would be located on the central hub that could roll the tarp open and the shut. One problem with this concept is that rolling up a tarp of this is difficult.



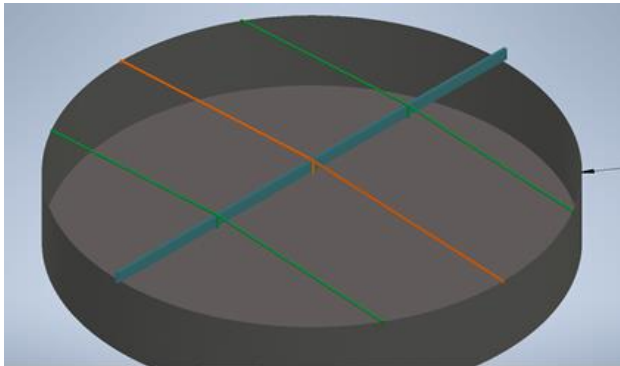
Concept 3 Continued:



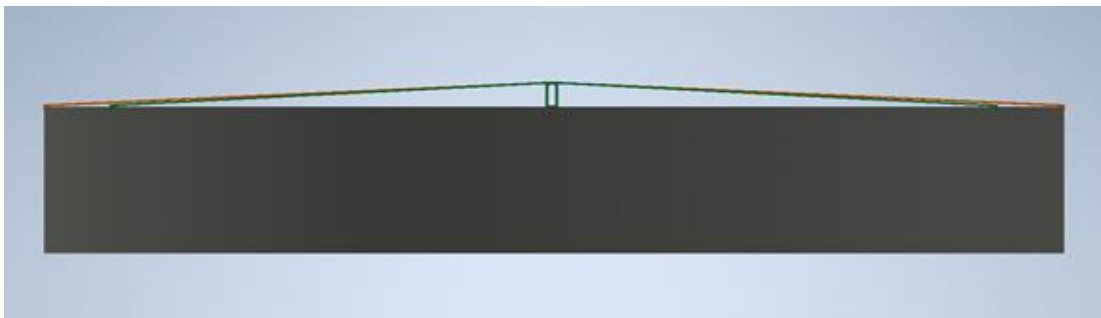
Pros	Cons
<ul style="list-style-type: none"> ○ Automatic tarp roller allows for easy opening and closing of tarp. ○ Most likely would not have to remove the tarp in the winter. 	<ul style="list-style-type: none"> ○ Requires power ○ Lots of moving parts that could malfunction ○ Complicated design with lots of moving parts.

○ **Concept 4:**

- Automatic Sliding Tarp - This concept involves a main beam that will span the distance of the tank. There will then be supporting beams that run from the main beam to the edges of the tank. The support beams will hold the tarp. Ideally there would be a motor and the tarp would roll up with the press of a button.



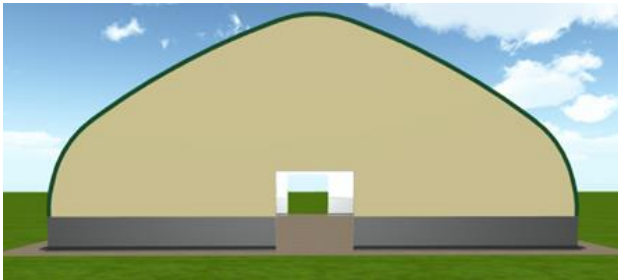
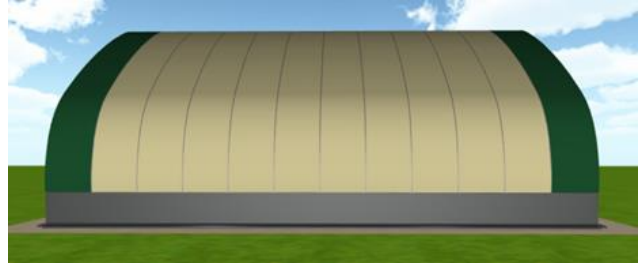
Pros	Cons
<ul style="list-style-type: none"> ○ Fully covers the tank ○ Doesn't require manual labor to remove cover ○ Can Be covered all winter. 	<ul style="list-style-type: none"> ○ Requires a large, heavy, expensive beam ○ Requires power to move cover ○ High ROI



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- **Concept 5:**

- Hoop/Pole Barn - This idea is the simplest. Put a hoop barn over the slurry tank. The sides do not need to be covered, and the roof would be high enough to fit the pumps under. The only reason this idea is not a viable option is because of price.



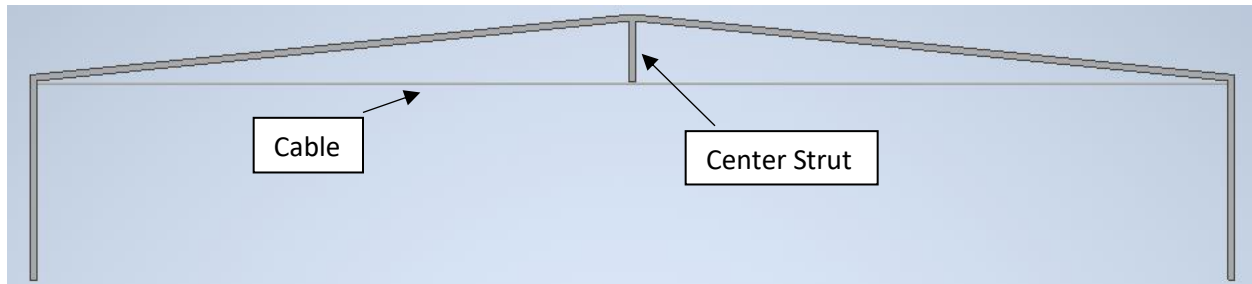
Pros	Cons
<ul style="list-style-type: none">○ Simplest Concept, contract a company to build the hoop barn.	<ul style="list-style-type: none">○ Expensive, ~\$137,000 from the quote that we received.

- **Estimating ROI**

- maximum savings of \$4,500. It then came to our attention that evaporation takes a portion of the collected rainwater out of the tank. The previous years' report stated that evaporation equals precipitation, but, in recent years, Iowa has seen increased rainfall, which leads to not all the rainwater being evaporated out of the tank. We have attempted to get in contact with somebody who would have knowledge of this but has got no response; we also cannot find any reliable articles or sources on the subject. So, with the information we have, we can deduce that a large portion of the collected rainwater in a tank will be evaporated out by natural processes, which will greatly reduce the cost savings. If we say that 50% of the rainwater is evaporated out of the tank, that splits the calculated cost savings in half. Cost savings goes from \$4,500 to \$2,250. If an ROI of 16 years is requested, then the total allowed budget for a cover is equal to \$2,250 times 16 years, which equals \$36,000. This budget must allow for the cost of materials, the cost to manufacture, cost to install, and cost of repairs over the expected life of the cover. From the quotes received from distributors, \$36,000 is not enough to cover all those costs. It is our team's opinion that there are not enough cost savings available to make putting a cover over manure storage structures feasible and worthwhile.

- **Center Strut and Cable**

- One aspect of the cover not in the above picture is the center strut and cable.
- This portion of the frame is crucial for structural integrity.
- The idea behind the center strut and cable is that a cable will run from one leg to the leg opposite it. An aluminum beam, known as the center strut, will then be connected to the frame peak and the cable which will create tension and provide structural support for the frame. (see picture below)



- **Contacts for next Capstone Team**

- Travis Hosteng – ISU Associate Professor: Helped with structural analysis of frame and gave recommendations to make it stronger. Should contact him if there are questions about tank structure.
- Dr. Daniel Andersen – ISU Associate Professor: Dr. Andersen specializes in manure management and water quality. Multiple attempts were made to contact him but he never responded. Never the less, he should be contacted with questions regarding evaporation from manure tanks.
- Shelter – Clear span tent company: This is the site where some ideas for the structure were pulled from. The following link is a video on installation of the tents and is a good example of the designed structure in this report.
<https://www.youtube.com/watch?v=aBiePlibF64>
- Blue Peak Tents - <https://bluepeaktents.com/>: Tent rental company that was used for ideas.